

Exhibit 10 to Complaint
Intellectual Ventures I LLC and Intellectual Ventures II LLC

Example Southwest Count 3 Systems and Services
U.S. Patent No. 7,949,785 (“the ’785 Patent”)

The Accused Systems and Services include without limitation Southwest systems and services that utilize Kubernetes; all past, current, and future systems and services that operate in the same or substantially similar manner as the specifically identified systems and services; and all past, current, and future Southwest systems and services that have the same or substantially similar features as the specifically identified systems and services (“Example Southwest Count 3 Systems and Services” or “Southwest Systems and Services”).¹

On information and belief, the Southwest Systems and Services use Kubernetes in its private cloud(s). For example, Southwest posts, or has posted, job opportunities that require familiarity with Kubernetes concepts.

See <https://www.linkedin.com/in/madhuker-daraboina-0038001a5/>, job profile of Senior DevOps/Cloud Engineer stating use of Kubernetes. (last accessed 9/24/24).

See <https://www.linkedin.com/in/abhijitroy18/>, job profile of Platform engineer stating use of Kubernetes. (last accessed 9/24/24).

See <https://www.linkedin.com/in/hammad--raza/>, job profile of senior security engineer stating use of Kubernetes. (last accessed 9/24/24).

See <https://www.linkedin.com/in/saikumar-kada-a8b884135/>, job profile of senior tech ops Engineer listing Kubernetes as a skill for Southwest position. (last accessed 9/24/24).

As another example, Southwest has stated that it is investing in cloud technology and has “moved about 50% of its technology” to the cloud and has indicated cloud migration is one of its areas of focus for 2024 and beyond. Source:

<https://www.phocuswire.com/southwest-airlines-cio-tech-investment>.

¹ For the avoidance of doubt, Plaintiffs do not accuse public clouds of Southwest if those services are provided by a cloud provider with a license to Plaintiffs’ patents that covers Southwest’s activities. IV will provide relevant license agreements for cloud providers in discovery. To the extent any of these licenses are relevant to Southwest’s activities, Plaintiffs will meet and confer with Southwest about the impact of such license(s).

On information and belief, other information confirms Southwest uses Kubernetes technology.



Top Airlines, Airports & Air Services Companies Using Kubernetes

29,575 companies using this technology

By [Kubernetes](#)

Kubernetes is an open-source system for automating deployment, scaling, and management of containerized applications.



Southwest Airlines

Technologies used by the company: 1,161

Source: <https://www.zoominfo.com/tech/23715/kubernetes-tech-from-transportation-airline-industry-by-revenue>.²

² All sources cited in this document were publicly accessible as of the filing date of the Complaint.

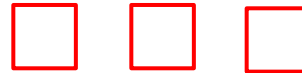
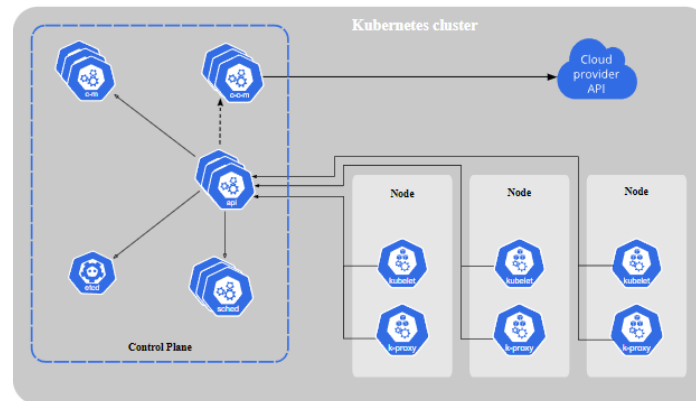
U.S. Patent No. 7,949,785 (Claim 30)	
Claim(s)	Example Southwest Count 3 Systems and Services
[30.pre] A virtual network manager, comprising:	<p>To the extent this preamble is limiting, on information and belief, the Southwest Count 3 Systems and Services include a virtual network manager.</p> <p>The virtual network manager is the Kubernetes functionality related to DNS for Services and Pods.</p> <p><u>DNS for Services and Pods</u></p> <p><u>Kubernetes creates DNS records for Services and Pods.</u> You can contact Services with consistent DNS names instead of IP addresses.</p> <p>Kubernetes publishes information about Pods and Services which is used to program DNS. Kubelet configures Pods' DNS so that running containers can lookup Services by name rather than IP.</p> <p><u>Services defined in the cluster are assigned DNS names.</u> By default, a client Pod's DNS search list includes the Pod's own namespace and the cluster's default domain.</p> <p>See https://kubernetes.io/docs/concepts/services-networking/dns-pod-service/#pod-s-dns-config.</p> <p><u>A Service in Kubernetes is an abstraction which defines a logical set of Pods</u> and a policy by which to access them. Services enable a loose coupling between dependent Pods. A Service is defined using YAML or JSON, like all Kubernetes object manifests. The set of Pods targeted by a Service is usually determined by a <i>label selector</i> (see below for why you might want a Service without including a <i>selector</i> in the spec).</p> <p>See https://kubernetes.io/docs/tutorials/kubernetes-basics/expose/expose-intro/.</p> <p><u>Kubernetes assigns this Service an IP address (the <i>cluster IP</i>), that is used by the virtual IP address mechanism.</u> For more details on that mechanism, read Virtual IPs and Service Proxies.</p> <p>See https://kubernetes.io/docs/concepts/services-networking/service/.</p>

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Claim(s)	Example Southwest Count 3 Systems and Services
	<p><u>Virtual IPs and Service Proxies</u></p> <p>Every node in a Kubernetes cluster runs a kube-proxy (unless you have deployed your own alternative component in place of kube-proxy).</p> <p>The kube-proxy component is responsible for implementing a virtual IP mechanism for Services of type other than ExternalName .</p> <p>See https://kubernetes.io/docs/reference/networking/virtual-ips/.</p>
[30.a] a network interface configured for data communication via a virtual network that is defined by a domain name having an associated public network address;	<p>On information and belief, the Southwest Count 3 Systems and Services include a network interface configured for data communication via a virtual network that is defined by a domain name having an associated public network address.</p> <p>On information and belief, Kubernetes DNS for Services and pods is implemented in part through a network interface called kube-proxy, which maintains network rules that allow communication to pods from network sessions. Kube-proxy communications can relate to network sessions inside or outside of the cluster in which the services are defined. The services defined in the cluster are assigned DNS names having an associated public network address.</p> <p>Kubernetes Components</p>

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Claim(s)

Example Southwest Count 3 Systems and Services



kube-proxy


kube-proxy is a network proxy that runs on each node in your cluster, implementing part of the Kubernetes Service concept.

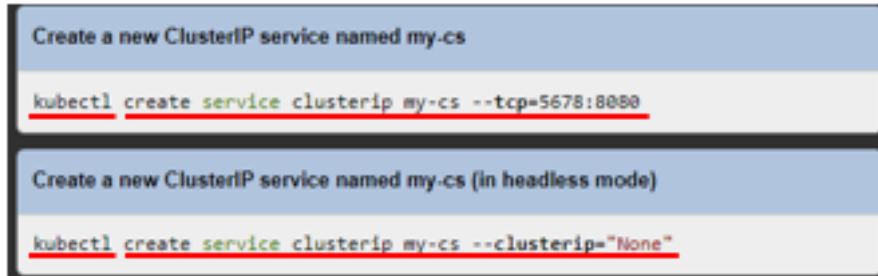
kube-proxy maintains network rules on nodes. These network rules allow network communication to your Pods from network sessions inside or outside of your cluster.

Source:


<https://kubernetes.io/docs/concepts/overview/components/#:~:text=kube%2Dproxy%20is%20a%20network,or%20outside%20of%20your%20cluster.>


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Claim(s)	Example Southwest Count 3 Systems and Services
	<p>DNS</p> <p>A cluster-aware DNS server, such as CoreDNS, watches the Kubernetes API for new Services and creates a set of DNS records for each one. If DNS has been enabled throughout your cluster then <u>all Pods should automatically be able to resolve Services by their DNS name.</u></p> <p>External IPs</p> <p>If there are external IPs that route to one or more cluster nodes, Kubernetes Services <u>can be exposed on those externalIPs</u>. When network traffic arrives into the cluster, with the external IP (as destination IP) and the port matching that Service, rules and routes that Kubernetes has configured ensure that the traffic is routed to one of the endpoints for that Service.</p> <p>Source: https://kubernetes.io/docs/concepts/services-networking/service/.</p> <p>DNS for Services and Pods</p> <p>Kubernetes creates DNS records for Services and Pods. You can contact <u>Services with consistent DNS names</u> instead of IP addresses.</p> <p><u>Services defined in the cluster are assigned DNS names.</u> By default, a client Pod's DNS search list includes the Pod's own namespace and the cluster's default domain.</p> <p>Source: https://kubernetes.io/docs/concepts/services-networking/dns-pod-service/#pod-s-dns-config.</p>
[30.b] a memory and a processor to implement a register module configured to register devices in a virtual	<p>On information and belief, the Southwest Count 3 Systems and Services include a memory and a processor to implement a register module configured to register devices in a virtual network.</p> <p>On information and belief, a service runs on a set of pods. The Kubernetes DNS Service module watches the Kubernetes API for incoming new services and creates a set of DNS records for each of the pods associated with the service.</p>

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Claim(s)	Example Southwest Count 3 Systems and Services
network, the register module further configured to:	<p>Kubernetes runs your workload by placing containers into Pods to run on <i>Nodes</i>. A node may be a <u>virtual or physical machine, depending on the cluster. Each node is managed by the control plane and contains the services necessary to run Pods.</u></p> <p>Source: https://kubernetes.io/docs/concepts/architecture/nodes.</p> <p>Initializing your control-plane node</p> <p>The control-plane node is the machine where the control plane components <u>run, including etcd (the cluster database) and the API Server (which the kubectl command line tool communicates with).</u></p> <p>Source: https://kubernetes.io/docs/setup/production-environment/tools/kubeadm/create-cluster-kubeadm/.</p> <p><u>DNS</u> </p> <p>You can (and almost always should) set up a <u>DNS service for your Kubernetes cluster using an add-on.</u></p> <p><u>A cluster-aware DNS server, such as CoreDNS, watches the Kubernetes API for new Services and creates a set of DNS records for each one. If DNS has been enabled throughout your cluster then all Pods should automatically be able to resolve Services by their DNS name.</u></p> <p>For example, if you have a Service called <code>my-service</code> in a Kubernetes namespace <code>my-ns</code>, <u>the control plane and the DNS Service acting together create a DNS record for <code>my-service.my-ns</code>. Pods in the <code>my-ns</code> namespace should be able to find the service by doing a name lookup for <code>my-service</code> (<code>my-service.my-ns</code> would also work).</u></p> <p>Source: https://kubernetes.io/docs/concepts/services-networking/service.</p>

U.S. Patent No. 7,949,785 (Claim 30)	
Claim(s)	Example Southwest Count 3 Systems and Services
	<p>Services in Kubernetes</p> <p>The Service API, part of Kubernetes, is an abstraction to help you expose <u>groups of Pods over a network. Each Service object defines a logical set of endpoints (usually these endpoints are Pods) along with a policy about how to make those pods accessible.</u></p> <p>For example, consider a stateless image-processing backend which is running with 3 replicas. Those replicas are fungible—frontends do not care which backend they use. While the actual Pods that compose the backend set may change, the frontend clients should not need to be aware of that, nor should they need to keep track of the set of backends themselves.</p> <p>The Service abstraction enables this decoupling.</p> <p>The set of Pods targeted by a Service is usually determined by a <u>selector</u> that you define. To learn about other ways to define Service endpoints, see Services without selectors.</p>
[30.b.i] receive a registration request from an agent associated with a device;	<p>On information and belief, the Southwest Count 3 Systems and Services include a register module configured to receive a registration request from an agent associated with a device.</p> <p>On information and belief, a service runs on a set of pods. The Kubernetes DNS Service module watches the Kubernetes API for incoming new services being made from the kubelet.</p>  <p>Source: https://kubernetes.io/docs/reference/generated/kubect/kubectl-commands.</p>

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Claim(s)	Example Southwest Count 3 Systems and Services
	<p><u>Discovering services</u></p> <p>For clients running inside your cluster, Kubernetes supports two primary modes of finding a Service: environment variables and <u>DNS</u>.</p> <p>DNS</p> <p>You can (and almost always should) set up a DNS service for your Kubernetes cluster using an <u>add-on</u>.</p> <p><u>A cluster-aware DNS server, such as CoreDNS, watches the Kubernetes API for new Services and creates a set of DNS records for each one. If DNS has been enabled throughout your cluster then all Pods should automatically be able to resolve Services by their DNS name.</u></p> <p>For example, if you have a Service called <code>my-service</code> in a Kubernetes namespace <code>my-ns</code>, the control plane and the DNS Service acting together create a DNS record for <code>my-service.my-ns</code>. Pods in the <code>my-ns</code> namespace should be able to find the service by doing a name lookup for <code>my-service</code> (<code>my-service.my-ns</code> would also work).</p> <p>Source: https://kubernetes.io/docs/concepts/services-networking/service.</p> <p>Services in Kubernetes</p> <p>The Service API, part of Kubernetes, is an abstraction to help you expose groups of Pods over a network. <u>Each Service object defines a logical set of endpoints (usually these endpoints are Pods) along with a policy about how to make those pods accessible.</u></p> <p><u>Defining a Service</u></p> <p>A Service is an <u>object</u> (the same way that a Pod or a ConfigMap is an object). You can <u>create, view or modify Service definitions using the Kubernetes API. Usually you use a tool such as kubectl to make those API calls for you.</u></p> <p>Source: https://kubernetes.io/docs/concepts/services-networking/service.</p>

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Claim(s)	Example Southwest Count 3 Systems and Services
	 <p>Source: https://kubernetes.io/docs/reference/kubectl/quick-reference/.</p> <p>See also https://kubernetes.io/docs/setup/production-environment/tools/kubeadm/create-cluster-kubeadm/.</p>
[30.b.ii] distribute a virtual network address to the device when the device is registered in the virtual network, the device being identified to other devices in the virtual network by the virtual network address; and	<p>On information and belief, the Southwest Count 3 Systems and Services include a register module configured to distribute a virtual network address to the device when the device is registered in the virtual network, the device being identified to other devices in the virtual network by the virtual network address.</p> <p>On information and belief, a service runs on a set of pods. A new service is assigned to a cluster IP, and as part of configuration, the Kubernetes DNS Service module distributes the network address to at least one pod on which the service runs.</p> <p>Using a Service to Expose Your App</p> <p>Although each Pod has a unique IP address, those IPs are not exposed outside the cluster without a Service. Services allow your applications to receive traffic. Services can be exposed in different ways by specifying a <code>type</code> in the <code>spec</code> of the Service:</p> <ul style="list-style-type: none"> • <u>ClusterIP (default)</u> - Exposes the Service on an internal IP in the cluster. This type makes the Service only reachable from within the cluster. <p>Source: https://kubernetes.io/docs/tutorials/kubernetes-basics/expose/expose-intro/.</p> <p>Service ClusterIP allocation</p> <p>In Kubernetes, <u>Services</u> are an abstract way to expose an application running on a set of Pods. <u>Services can have a cluster-scoped virtual IP address (using a Service of type: ClusterIP).</u> Clients can connect using that virtual IP address, and Kubernetes then load-balances traffic to that Service across the different backing Pods.</p>

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Claim(s)	Example Southwest Count 3 Systems and Services
	<p>Source: https://kubernetes.io/docs/concepts/services-networking/cluster-ip-allocation/.</p> <p>VIP</p> <p><u>a virtual IP address, such as the one assigned to every Service in Kubernetes</u></p> <p>Source: https://kubernetes.io/docs/tutorials/services/source-ip/.</p> <p>DNS </p> <p>You can (and almost always should) set up a <u>DNS service for your Kubernetes cluster</u> using an <u>add-on</u>.</p> <p>A cluster-aware DNS server, such as CoreDNS, watches the Kubernetes API for new Services and creates a set of DNS records for each one. If DNS has been enabled throughout your cluster then all Pods should automatically be able to resolve Services by their DNS name.</p> <p>For example, if you have a Service called <code>my-service</code> in a Kubernetes namespace <code>my-ns</code>, the control plane and the DNS Service acting together create a DNS record for <code>my-service.my-ns</code>. Pods in the <code>my-ns</code> namespace should be able to <u>find the service</u> by doing a name lookup for <code>my-service</code>. (<code>my-service.my-ns</code> would also work).</p> <p>Source: https://kubernetes.io/docs/concepts/services-networking/service.</p>

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Claim(s)	Example Southwest Count 3 Systems and Services
	<div style="text-align: center;"> resolv.conf(5) File Formats Manual resolv.conf(5) </div> <p>NAME top</p> <p><u>resolv.conf - resolver configuration file</u></p> <p>SYNOPSIS top</p> <p><u>/etc/resolv.conf</u></p> <p>DESCRIPTION top</p> <p>The resolver is a set of routines in the C library that provide access to the Internet Domain Name System (DNS). The resolver configuration file contains information that is read by the resolver routines the first time they are invoked by a process. The file is designed to be human readable and contains a list of keywords with values that provide various types of resolver information. The configuration file is considered a trusted source of DNS information; see the trust-ad option below for details.</p> <p>Source: https://man7.org/linux/man-pages/man5/resolv.conf.5.html.</p> <h2 style="text-decoration: underline red;">Using CoreDNS for Service Discovery</h2> <h3>About CoreDNS</h3> <p><u>CoreDNS is a flexible, extensible DNS server that can serve as the Kubernetes cluster DNS.</u> Like Kubernetes, the CoreDNS project is hosted by the CNCF.</p> <p>You can use CoreDNS instead of kube-dns in your cluster by replacing kube-dns in an existing deployment, or by using tools like kubeadm that will deploy and upgrade the cluster for you.</p> <p>Source: https://kubernetes.io/docs/tasks/administer-cluster/coredns/.</p>

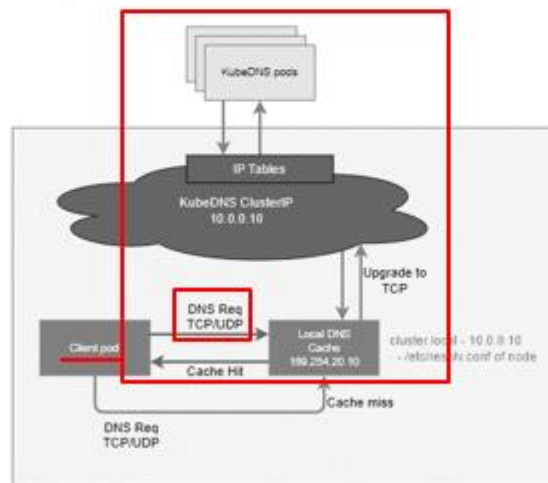
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Claim(s)

Example Southwest Count 3 Systems and Services

Introduction

NodeLocal DNSCache improves Cluster DNS performance by running a DNS caching agent on cluster nodes as a DaemonSet. In today's architecture, Pods in 'ClusterFirst' DNS mode reach out to a kube-dns serviceIP for DNS queries. This is translated to a kube-dns/CoreDNS endpoint via iptables rules added by kube-proxy. With this new architecture, Pods will reach out to the DNS caching agent running on the same node, thereby avoiding iptables DNAT rules and connection tracking. The local caching agent will query kube-dns service for cache misses of cluster hostnames ("cluster.local" suffix by default).



Source: <https://kubernetes.io/docs/tasks/administer-cluster/nodelocaldns/>.

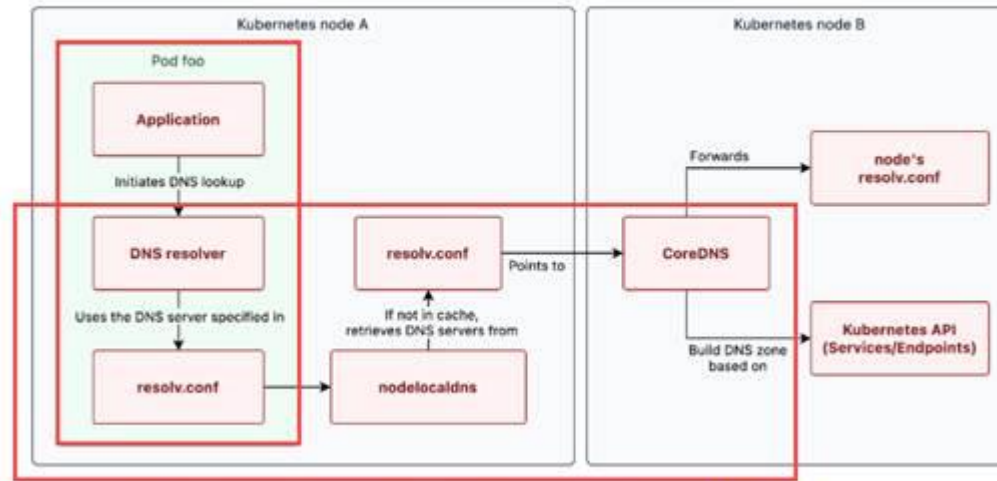
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Claim(s)	Example Southwest Count 3 Systems and Services
	<p>Pod foo</p> <p>When a pod sends an API request to a service within the same Kubernetes cluster, it must first resolve the IP address of the service. To do this, the pod performs a DNS lookup using the DNS server specified in its <code>/etc/resolv.conf</code> configuration file.</p> <p>This file, which is provisioned by the Kubelet, defines the settings for DNS lookups in the pod. It contains a reference to the cluster DNS server.</p> <p>By default, this configuration file looks something like this:</p> <pre>search namespace.svc.cluster.local svc.cluster.local cluster.local nameserver 10.123.0.10 options ndots:5</pre> <p>Source: https://www.nslookup.io/learning/the-life-of-a-dns-query-in-kubernetes/.</p>

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Claim(s)

Example Southwest Count 3 Systems and Services

DNS lookups on services



The flow of a DNS query in Kubernetes. By Nslookup.io, Licensed under [CC By 4.0](https://creativecommons.org/licenses/by/4.0/).



Source: <https://www.nslookup.io/learning/the-life-of-a-dns-query-in-kubernetes/>.

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Claim(s)	Example Southwest Count 3 Systems and Services
	<p>When a pod performs a DNS lookup, the query is first sent to the local DNS resolver in the pod. This resolver uses the resolv.conf configuration file. In this file, the nodeLocalDNS server is set up as the default recursive DNS resolver, which acts as a cache.</p> <p>If this cache does not contain the IP address for the requested hostname, the query is forwarded to the cluster DNS server (CoreDNS).</p> <p>This DNS server determines the IP address by consulting the Kubernetes service registry. This registry contains a mapping of service names to their corresponding IP addresses. This allows the cluster DNS server to return the correct IP address to the requesting pod.</p> <p>Any domains that are queried but are not in the Kubernetes service registry are forwarded to an upstream DNS server.</p> <p>We will go through each of these components in more detail step-by-step.</p> <p>Source: https://www.nslookup.io/learning/the-life-of-a-dns-query-in-kubernetes/.</p> <p>On information and belief, Southwest's systems include "a private network address associated with a second device in the virtual network, and a virtual network address associated with the second device."</p> <p>On information and belief, the private network address associated with a second device is a unique private IP address assigned to a backend node. The virtual network address associated with the second device is the Cluster IP or Virtual IP assigned to a pod (or pods) and/or container (or containers).</p>

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Example Southwest Count 3 Systems and Services

 CoreDNS 

kubernetes

[Source](#)

kubernetes enables reading zone data from a Kubernetes cluster.

Description

This plugin implements the [Kubernetes DNS-Based Service Discovery Specification](#).

CoreDNS running the kubernetes plugin can be used as a replacement for kube-dns in a kubernetes cluster. See the [deployment](#) repository for details on [how to deploy CoreDNS in Kubernetes](#).

 CoreDNS

Metadata

The kubernetes plugin will publish the following metadata, if the metadata plugin is also enabled:

- `kubernetes/endpoint`: the endpoint name in the query
- `kubernetes/kind`: the resource kind (pod or svc) in the query
- `kubernetes/namespace`: the namespace in the query
- `kubernetes/port-name`: the port name in an SRV query
- `kubernetes/protocol`: the protocol in an SRV query
- `kubernetes/service`: the service name in the query
- `kubernetes/client-namespace`: the client pod's namespace (see requirements below)
- `kubernetes/client-pod-name`: the client pod's name (see requirements below)

The `kubernetes/client-namespace` and `kubernetes/client-pod-name` metadata work by reconciling the client IP address in the DNS request packet to a known pod IP address. Therefore the following is required:

- `pods-verified` mode must be enabled
- the remote IP address in the DNS packet received by CoreDNS must be the IP address of the Pod that sent the request.

Source: <https://coredns.io/plugins/kubernetes/>.

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Claim(s)	Example Southwest Count 3 Systems and Services
	<p>Connecting Applications with Services</p> <p>Kubernetes assumes that pods can communicate with other pods, regardless of which host they land on. <u>Kubernetes gives every pod its own cluster-private IP address</u>, so you do not need to explicitly create links between pods or map container ports to host ports. This means that containers within a Pod can all reach each other's ports on localhost, and all pods in a cluster can see each other without NAT. The rest of this document elaborates on how you can run reliable services on such a networking model.</p> <p>Source: https://kubernetes.io/docs/tutorials/services/connect-applications-service/.</p> <p>Using a Service to Expose Your App</p> <p>Although each Pod has a unique IP address, those IPs are not exposed outside the cluster <u>without a Service</u>. <u>Services allow your</u> applications to receive traffic. Services can be exposed in different ways by specifying a <code>type</code> in the <code>spec</code> of the Service:</p> <ul style="list-style-type: none"> • <u>ClusterIP</u> (default) - Exposes the Service on an internal IP in the cluster. This type makes the Service only reachable from within the cluster. <p>Source: https://kubernetes.io/docs/tutorials/kubernetes-basics/expose/expose-intro/.</p> <p>Service ClusterIP allocation</p> <p>In Kubernetes, <u>Services</u> are an abstract way to expose an application running on a set of Pods. Services can have a cluster-scoped virtual IP address (using a Service of <code>type: ClusterIP</code>). Clients can connect <u>using that virtual IP address</u>, and Kubernetes then load-balances traffic to that Service across the different backing Pods.</p> <p>Source: https://kubernetes.io/docs/concepts/services-networking/cluster-ip-allocation.</p>